IMPROVEMENT OF PAK CHOI (*Brassicca Rapa Var. Chinensis*) GROWTH IN ACIDIC SOIL USING FERMENTED LIQUID ORGANIC FERTILIZER PRODUCED FROM UNMARKETABLE VEGETABLES

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirements of the Degree of Master of Science

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DEDICATION

I dedicate this thesis to the unwavering support and encouragement of my family. Your love and belief in me have been the driving force behind this journey. To my parents, whose sacrifices and guidance have shaped my path, and to my siblings, who have cheered me on every step of the way—thank you for being my pillars of strength.

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Sanjeev MP Ramarao

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

IMPROVEMENT OF PAK CHOI (*Brassicca Rapa Var. Chinensis*) GROWTH IN ACIDIC SOIL USING FERMENTED LIQUID ORGANIC FERTILIZER PRODUCED FROM UNMARKETABLE VEGETABLES

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ABSTRACT

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The Malaysian government is facing significant challenges related to managing food waste, a concern that contributes to greenhouse gas emissions in landfills. This waste, however, contains valuable nutrients that, when harnessed through fermentation, can yield liquid organic fertilizer (LOF). This fertilizer has the potential to enhance soil quality by addressing issues such as low cation exchange capacity, pH imbalances, and insufficient mineral nutrient content, directly impacting crop productivity. This research encompasses two primary experiments: the first involves characterizing the LOF derived from food waste collected from nearby wet markets, particularly unmarketable vegetables and fruits, which undergoes wet anaerobic fermentation in a 1:2 ratio with water. The second experiment aims to explore the impact of LOF on the growth and yield of pak choi vegetables. For experiment 1, the food waste derived from unmarketable vegetables and fruits was identified, collected from the nearest wet market, and fermented under wet anaerobic with a ratio of 1:2 (food waste: water). The food waste was fermented separately under three inducers: T2- yeast: T3- brown sugar, and T4- shrimp paste to boost the fermentation process and without inducer acting as a T1-control. Liquid organic fertilizers were sampled at 30 (30D), 45 (45D), and 60 (60D) days of fermentation and analyzed for nutrient content. These experiments were laid in a randomized complete block design (RCBD) and replicated three times. Results of the LOF derived from unmarketable vegetables through fermentation for 60 days using yeast as an inducer showed the highest nitrogen (0.95%), phosphorus (0.31%), and potassium (1.68%). Therefore, the LOF using yeast as an inducer was further for experiment 2. It consisted of seven treatments; T1- NPK (15-15-15) fertilizer; T2- 100% of LOF (30D); T3- 100% of LOF (45D); T4- 100% of LOF (60D); T5- 50% of LOF (30D) + 50% NPK; T6-50% of LOF (45D) + 50% NPK; and T7- 50% of LOF (60D) + 50% NPK. The experiment was arranged using Completely Randomized Design (CRD) with 5 replications. The findings from the second experiment revealed that soil treated with 50% LOF of 60D+ 50% NPK (T7) application was shown to give positive results in soil pH, cation exchange capacity (CEC), organic matter (OM), and soil catalase activity measured at the

harvest stage which increased by 18.27%, 30.15%, 44.55%, and 5.26%, respectively compared to the before-harvest stage soil. Meanwhile, T7 also increases plant height, fresh weight, total chlorophyll, and total flavonoid content at 5.88%, 6.12%, 1.12%, and 0.25%, respectively. Besides, leaf area and dry weight were 46.36 cm2 and 0.88 g, respectively, which do not significantly different from standard fertilizer, Treatment 1. It can be concluded that the integration of organic and chemical nutrient inputs showed better results in providing a more balanced supply of nutrients.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENINGKATAN PERTUMBUHAN PAK CHOI (*Brassicca Rapa Var. Chinensis*) DALAM TANAH ASID MENGGUNAKAN PUPUK ORGANIK CECAIR FERMENTASI YANG DIHASILKAN DARI SAYUR-SAYURAN DAN BUAH-BUAHAN TIDAK DAPAT DIPASARKAN

Oleh

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Kerajaan Malaysia menghadapi cabaran besar berkaitan pengurusan sisa makanan, satu kebimbangan yang menyumbang kepada pelepasan gas rumah hijau di tapak pembuangan sampah. Namun, sisa ini mengandungi nutrien bernilai yang apabila dimanfaatkan melalui proses fermentasi, boleh menghasilkan baja organik cecair (BOC). Baja ini berpotensi untuk meningkatkan kualiti tanah dengan menangani isu seperti kapasiti pertukaran kation yang rendah, ketidakseimbangan pH, dan kandungan nutrien mineral yang tidak mencukupi, dengan kesan langsung terhadap produktiviti tanaman. Penyelidikan ini melibatkan dua eksperimen utama: yang pertama melibatkan pencirian BOC yang berasal daripada sisa makanan yang dikutip dari pasar basah berdekatan, terutamanya sayur-sayuran dan buah-buahan tidak laku, yang mengalami proses fermentasi anaerobik basah dalam nisbah 1:2 dengan air. Eksperimen kedua bertujuan untuk menyelidik impak BOC terhadap pertumbuhan dan hasil sayur-sayuran pak choi. Sisa sayur-sayuran dan buah-buahan diambil dari pasar basah terdekat dan diperamin dalam tong mengikut nisbah 1:2 (10 kg sisa makanan: 20 L air). Tiga jenis penggalak berbeza iaitu ragi, gula merah dan belacan turut dicampurkan secara berasingan tong peraman bagi meningkatkan proses fermentasi. Sisa makanan tanpa pemangkin adalah rawatan kontrol. Rawatan kawalan bagi kajian ini adalah sisa makanan tanpa penggalak. Hasil BOC diambil pada 30, 45, dan 60 hari digunakan untuk analisis. Keputusan kajian menunjukkan BOC yang diperolehi daripada sisa makanan melalui fermentasi selama 60 hari menggunakan ragi mempunyai kandungan nitrogen tertinggi (0,95%), fosforus (0,31%), dan kalium (1.68%). Selain itu, rawatan ini menujukkan nilai pH dan EC yang optimum untuk pertumbuhan tumbuhan. Eksperimen kedua mengandungi tujuh rawatan iaitu; T1- baja NPK (15-15-15); T2- 100% BOC (30H); T3- 100% BOC (45H); T4- 100% of BOC (60H); T5- 50% of BOC (30H) + 50% NPK; T6-50% of BOC (45H) + 50% NPK; and T7- 50% of BOC (60H) + 50% NPK. Kajian eksperimen kedua menunjukkan bahawa pak choi yang dirawat dengan, 50% BOC 60 hari fermentasi dan 50% NPK menunjukkan prestasi yang lebih baik terhadap hasil

pH tanah, kapasiti pertukaran kation (CEC), bahan organik (OM), dan aktiviti katalas meningkat dengan 18.27%, 30.15%, 44.55% dan 5.26%. Sementara itu, T7 juga meningkatkan ketinggian tumbuhan, berat segar, jumlah klorofil, dan kandungan flavonoid total, 5.88%, 6.12%, 1.12%, and 0.25%. Di samping itu, keluasan daun dan berat kering adalah 46.36 cm2 dan 0.88 g, yang tidak berbeza secara signifikan daripada baja NPK standard, Rawatan 1. Kesimpulannya, campuran antara BOC dan baja kimia dapat memberikan hasil yang baik dan kandunagan nutrien yang lebih seimbang.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

CEC	Cation Exchange Capacity
◦C	Degree Celsius
EC	Electrical Conductivity
LOF	Liquid Organic Fertilizer
OM	Organic Matter
ppm	Part per million
SGD	Sustainable Development Goal
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Malaysia brought in RM55.5 billion worth of food imports in 2020 compared to the RM33.8 billion value of exports. The principal partners for Malaysia's vegetable imports in 2019 are Indonesia, China, the United States, Argentina, and Thailand (Razak, 2021). The National Agrofood Policy, (NAP) of Malaysia aims to ensure an adequate supply of nutritious food for the country. In order to achieve the objectives, urban agriculture is considered a solution to address the household livelihood strategies of urban households. Several government agencies, including the department of agriculture (DOA) and Universiti Putra Malaysia (UPM), have encouraged urban inhabitants to engage in urban agricultural activities (Rezai et al., 2016).

Due to the currency crisis and over-dependence on low-cost food imports, Malaysia has been forced to consider an alternative to cultivating fruits and vegetables through intense agricultural operations to promote self-sufficiency. In that case, through farmers' associations, the government offers smallholder farmers subsidies to help with the cost of fertilizers (FAO, 2019). Urban agriculture, followed by self-sufficiency, which achieved the food demands of the rising population, caused an increase in crop production but, at the same time, increased the use of chemical fertilizers in agriculture. Poor soil fertility is one of the most serious problems in improving agricultural production. However, the widespread use of inorganic fertilizers in agriculture to ensure global food security has led to many health issues and irreversible environmental degradation (Kumar et al.,2019).

Inorganic fertilizers are synthetic or mineral-based chemical products that supply nutrients to promote plant development. A plant can only use so much during its growth cycle; any excess tends to pollute the environment and cause problems. The exact amount of a specific element can be measured before feeding plants using inorganic fertilizer, although commercial fertilizer, especially nitrogen, can easily leach out by rain or irrigation (Ibrahim et al., 2014). The tendency of soil nutrients, a problem that plagues farms frequently, is something that inorganic fertilizers are made to combat. One of its distinct advantages is that inorganic fertilizer contains all three essential nutrients: nitrogen (N), phosphorus (P), and potassium (K).

In contrast to organic fertilizer, which only has a slow-release capacity, this sort of fertilizer can feed plants with nutrients immediately when needed. Organic fertilizers take longer to work and cannot be used more than a farm requires.

They can also be utilized in concentrated doses and are less expensive than commercial organic fertilizers (Ibrahim et al., 2014).

Alternative methods of providing nutrients to crops, such as using organic fertilizers and biofertilizers, should be encouraged to counteract the detrimental impacts of the intensive use of chemical fertilizers. Animal manure and litter, agricultural by-products, fresh or dried plant material, and other plant-derived substances are all included in organic fertilizers (Kumar et al., 2005). The number of nutrients in organic fertilizers varies widely depending on the materials used as their sources, and materials that can break down quickly are the best options. Compared to chemical fertilizers, organic fertilizers often include less N and P. The relevance of an organic fertilizer's carbon content can be equal to or even more than its N and P amounts. Organic fertilizer applications also enhance secondary and primary productivity by mineralizing nutrients and encouraging increases in heterotrophic bacterial biomass (Barkoh et al., 2005).

Liquid organic fertilizers can benefit from more efficient N use when applied through a drip irrigation system; such an application is called fertigation. Any nutrient in a water-soluble form is immediately available for plant absorption, resulting in the more effective use of fertilizers (Miles et al., 2019). Farmers can minimize nutrient loss from the root zone by applying nutrients just before they are needed. These liquid fertilisers can be applied often depending on the crop's nutritional requirements. Some liquid fertilizer components from soybean or fish are used extensively in growing organic vegetables.

Food waste can be categorized as unconsumed food substances that are disposed of or recycled. It is generated from households, markets, hawker centres, supermarkets, and food courts (Bratovcic et al., 2018). Food wastage can be calculated by more than 1.3 billion tonnes of food each year. Food waste or food loss is wasted, lost or uneaten food. Food waste or loss causes are numerous and occur at the producing, processing, retailing, and consuming stages.

In Malaysia, handling and treating food waste presents significant issues for the government. Food waste contributes to the current environmental problem since it is improperly segregated from municipal solid trash and creates greenhouse gases in landfills. Food waste may release greenhouse gases that have an adverse effect on climate change (Thi et al., 2015). Campaigns like the 3R (Reduce, Reuse, and Recycle) have been launched to raise public awareness through education and incentive-based policies. Effective food waste reduction is made possible by proper food waste management.

Food wastes can be recycled into organic fertilizer to limit the amount of food waste in landfills and the emission of greenhouse gases into the environment. Microorganisms can break down food waste into smaller materials during

anaerobic digestion to create usable goods. For the information, the disposed food wastes have high nutrient content that may be used as a fermentation substrate to produce other value-added products such as new planting crops (Bratovcic et al., 2018).

1.2 Justification

In recent years, there has been a growing interest in the scientific community regarding the substantial portion of organic material represented by food waste. Malaysia is well known among foreign tourists for its vast assortment of traditional and modern cuisine and its rich cultural history. While these popular attractions have the potential to boost the country's economy, the governing body has encountered formidable difficulties for many years regarding the management and disposal of food waste (Hashim et al., 2021). This also can be related to the population growth and urbanization occurring within Malaysia, which have led to elevated living standards and increased waste (Noor et al., 2013).

Waste from fruits and vegetables (FVW) is produced during various stages, including transportation, harvesting, food industry processing, storage, and marketing. Significant quantities of FVW can typically be found in the marketplace (Seswoya et al., 2019). For decades, landfills have been the primary means of disposing of municipal solid waste. The high volatility of solids and water content in FVW poses significant environmental challenges due to their strong biodegradable nature, releasing foul odours and substantial leachate in landfills in the marketplace (Lin et al., 2011).

However, FVW consists of high moisture content, readily biodegradable with high nutrient contents that serve as the perfect substrate for fermentation. The valuable nutrients in FVW can be used to achieve impressive fermentation performance, producing organic liquid fertilizer. In Malaysia, the daily production rate of municipal solid waste ranges between 0.8 kg to 0.9 kg per household in highly populated cities, and 60 % of it consists of food waste. The FVW collection system from households and restaurants in Malaysia is poor, far from other countries' collection systems. For example, in Hong Kong, food waste will be separated in the household in dark plastic bags, which can easily be differentiated from the other waste packed in white plastic bags (Chua et al., 2019).

These problems occur in Malaysia due to a lack of food waste awareness. Besides, most people in Malaysia do not understand the nutrient content in food waste and its use of it. Therefore, this study is significant to justify the potential of producing liquid organic fertilizer from food waste as a source of nutrients for pak choy growth.

1.3 Objectives

This study was conducted with the following objectives:

1. To characterize the liquid organic fertilizer under different inducer and days of fermentation.

2. To determine the effects of liquid organic fertilizer on the growth, yield and nutrient content of pak choi.

3. To investigate the effects of liquid organic fertilizer on the soil.

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